An automated method for picking common-image-point gather locations

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Common-image-point gathers (CIP)
Common-image-gathers (CIGs)
What makes a good CIP location?

- coherent reflectors
- simple image structures
- center of reflectors
- sufficient sampling
Picking strategy

- create a priority map
- select locations using a greedy heuristic
Structure tensor

\[ T = \langle gg^T \rangle \]

\[ = \begin{bmatrix}
\langle g_x g_x \rangle & \langle g_x g_y \rangle \\
\langle g_x g_y \rangle & \langle g_y g_y \rangle 
\end{bmatrix} \]

[van Vliet, et. al., 1995]
[Hale, 2009]
Eigen-decomposition

\[ T = \lambda_u uu^T + \lambda_v vv^T \]

linearity: \[ \frac{\lambda_u - \lambda_v}{\lambda_u} \]
Structure tensor vectors
Structure-oriented semblance

\[ S_{V,u} = \frac{\langle \langle f \rangle_v^2 \rangle_u}{\langle \langle f^2 \rangle_v \rangle_u} \]

[Hale, 2009]
Priority map

\[ p_{cip} = p_l p_s p_e \]

- \( p_l \): linearity
- \( p_s \): semblance
- \( p_e \): envelope
Priority map
Greedy algorithm

“A greedy algorithm always makes the choice that looks best at the moment.”

[Cormen, 2001]
Greedy CIP picker

1. sort locations by priority
2. pick highest priority location
3. exclude neighboring locations
4. repeat steps 2 and 3
Isotropic exclusion-zone (IEZ)
Anisotropic exclusion-zone (AEZ)
Anisotropic exclusion-zone

\[ \nabla t(x) \cdot D(x) \cdot \nabla t(x) = 1 \]

\[ D = e_u uu^T + vv^T \]
Correct velocity image
Linearity measure clipped
Semblance measure
Semblance measure clipped
Envelope measure
Priority map

\[ p_{cip} = p_l p_s p_e p_m \]

- \( p_l \): linearity
- \( p_s \): semblance
- \( p_e \): envelope
- \( p_m \): mask
Greedy CIP picker

1. sort locations by priority
2. pick highest priority location
3. exclude neighboring locations
4. repeat steps 2 and 3
AEZ
Picks using IEZs
Picks using AEZs
Picking in 3D

(put your glasses on now)
SEAM image
Structure tensor 3D

\[ T = \langle gg^T \rangle \]

\[
= \begin{bmatrix}
\langle g_x g_x \rangle & \langle g_x g_y \rangle & \langle g_x g_z \rangle \\
\langle g_x g_y \rangle & \langle g_y g_y \rangle & \langle g_y g_z \rangle \\
\langle g_x g_z \rangle & \langle g_y g_z \rangle & \langle g_z g_z \rangle 
\end{bmatrix}
\]

[van Vliet, et. al., 1995]
[Hale, 2009]
Eigen-decomposition 3D

\[ T = \lambda_u uu^T + \lambda_v vv^T + \lambda_w ww^T \]

linearity: \[ \frac{\lambda_v - \lambda_w}{\lambda_u} \]

planarity: \[ \frac{\lambda_u - \lambda_v}{\lambda_u} \]
Planarity measure
Planarity measure clipped
Structure-oriented semblance

\[ S_{vw,u} = \frac{\langle \langle f \rangle_{vw}^2 \rangle_u}{\langle \langle f^2 \rangle_{vw} \rangle_u} \]

[Hale, 2009]
Semblance measure
Envelope measure
Priority map

\[ p_{cip} = ppppspepm \]

- \( p_p \): planarity
- \( p_s \): semblance
- \( p_e \): envelope
- \( p_m \): mask
Priority map
Greedy CIP picker

1. sort locations by priority
2. pick highest priority location
3. exclude neighboring locations
4. repeat steps 2 and 3
3D IEZ
3D AEZ
3D anisotropic exclusion-zone

\[ \nabla t(x) \cdot D(x) \cdot \nabla t(x) = 1 \]

\[ D = e_u uu^T + vv^T + ww^T \]
Picks
Conclusion

- coherent reflectors are favored
- simple image structures are favored
- center of reflectors are favored
- picks are well distributed
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